ECL
A QUAKER CHEMICAL COMPANY

Quick-Study for Product Design Engineers







Grease: More than Lubrication

Grease: *More than Lubrication*

Quick Overview

The primary function of any grease is to reduce friction and prevent wear, but greases can prove useful as product design tools in other ways as well.

This Quick-Study reviews how grease can be used to control motion and noise, provide a protective seal for parts, and even prolong ball bearing life by acting as a ground for static discharge.

The Basics: *What is grease and how does it work?*

Oil
(up to 90%)

Thickener
(15 to 30%)

Additives
(5 to 10%)

Solid Lubricants
(5 to 10%)

Oils lubricate. They form a protective film between two surfaces to prevent friction and wear.

Thickeners hold the oil in place, much like a sponge holds water. When mated parts move, the thickener is sheared and releases oil to form a lubricating film between moving parts. Thickeners reabsorb oil when motion stops.

Additives enhance critical performance qualities of a grease, such as low temperature torque, corrosion protection, and oxidation resistance.

Solid lubricants like PTFE, MoS_2, and graphite are load-carrying additives that improve the lubricity of a grease, especially on start-up.

“Damping greases” control motion, acoustics, and feel of mechanical parts

Damping grease started in optics

- The noiseless motion of metal on metal, the smooth “feel,” and the absence of coasting and backlash of focus controls on cameras and optical instruments are all the work of damping grease.
- Until the 1960s, damping grease had few applications in other industries because it often froze (i.e., became too viscous to shear) in cold temperatures.

Synthetic oils brought damping grease to other industries

- Damping greases made with synthetic oils can withstand temperatures from –54°C to 250°C , making them useful “design tools” for a variety of industries.
- Damping greases are now used to control motion, sound, and feel of interior, underhood, and underbody automotive parts; office printers and copiers; industrial and chemical process controls; outdoor recreation equipment; small household appliances; and other products that require smooth, quiet motion and precision tuning.

How design engineers are using damping greases

Automotive

- Ensures smooth, quiet operation of seat tracks and recliners.
- Reduces or eliminates noise with grab bars, window lifts, locks, sun roofs — and prevents coasting and backlash for head rests.
- Reduces vibration and noise from exterior power mirrors.
- Minimizes “knock” in rack and pinions and improves the “smooth feel” of the entire steering system.

Dials, Sliders, Switches

- Adds a “quality feel” and acoustic characteristics to hand-actuated devices without tight engineering tolerances or special materials.

Hinges

- Ensures smooth, quiet motion for laptop hinges, spring-loaded trays, stadium seating, and fine cabinets.

Plastic Gears

- Reduces rattle often heard in office printers and copiers.

How damping greases work: *It's all about shear*

Water
1 cSt.

Vegetable Oil
50 cSt.

Honey
2,000 cSt.

Kitchen Analogy

Compared to water, it takes more torque to stir, that is, shear through hot fudge because its Kinematic Viscosity* is 20,000 times higher than water.

The same principle applies to formulating a damping grease. Combining a high viscosity oil with a thickener makes a "stickier" grease with high internal shear resistance — the key to controlling motion and sound of moving parts within the grease.

Corn Syrup
5,000 cSt.

Molasses
20,000 cSt.

Hot Fudge
20,000 cSt.

*Kinematic Viscosity was measured at 25°C and reported in Centistokes.

- Like all grease, damping grease prevents friction and wear and acts as a barrier to moisture, dust, and other contaminants.
- A special purpose lubricant, damping greases are formulated with high-viscosity oils, which create a stickier grease with higher internal sheer resistance.
- As parts move and shear the damping grease, higher internal sheer resistance "damps" noise. It also controls how fast or slowly a part will move and ensures that when power stops the motion does too: no coasting or backlash.
- Damping greases can be formulated to meet motion and acoustic design specifications for most any mechanical device with the exception of very low powered devices, which on start-up may not be able to overcome the internal shear resistance of even the lightest damping grease.

Choosing any grease starts with temperature

Operating Temperatures for Oils

Mineral	-30 to 100°C
PolyAlphaOlefin (PAO) Synthetic HydroCarbon (SHC)	-60 to 150°C
Ester	-70 to 150°C
PolyAlkylene Glycol (PAG)	-40 to 180°C
Silicone	-75 to 200°C
PerFluoroPolyEther (PFPE)	-90 to 250°C

Check temperature range of the oil

- The temperature of the operating environment determines the type of oil you need in your grease. Temperatures below -30°C and higher than 100°C require a synthetic oil.
- As temperature ranges of the oil expand, cost increases. Temperature ranges are accurate. Don't "buy" more than you need "as a buffer."

Check oil compatibility with thickeners

How Thickeners Perform Under Operating Conditions

	Aluminum	Aluminum Complex	Amorphous Silica	Barium Complex	Bentonite	Calcium	Calcium Complex	Calcium Sulfonate	Lithium	Lithium Complex	Polyurea	PTFE	Sodium Complex
Adhesive	●	●	●	●	●	●	●	●	●	●	●	●	●
Autophoretic Paint Process	●	●	●	●	●	●	●	●	●	●	●	●	●
Corrosion	●	●	●	●	●	●	●	●	●	●	●	●	●
Dropping Point	●	●	●	●	●	●	●	●	●	●	●	●	●
Fretting	●	●	●	●	●	●	●	●	●	●	●	●	●
Low Friction	●	●	●	●	●	●	●	●	●	●	●	●	●
Salt Water	●	●	●	●	●	●	●	●	●	●	●	●	●
Water	●	●	●	●	●	●	●	●	●	●	●	●	●
Wear	●	●	●	●	●	●	●	●	●	●	●	●	●
Worked Stability	●	●	●	●	●	●	●	●	●	●	●	●	●

● Should be safe ● May or may not work ● Don't try it

Check oil and thickener compatibility

- Mineral, PAO, and ester oils mix with any thickener.
- Silicone oil mixes only with lithium, silica and PTFE.
- PFPE oil can be thickened only with PTFE.

Then, match thickener to operating environment:

- Polyurea adds extra water and corrosion protection.
- Silica offers superior performance at high temperatures.
- Calcium sulfonate protects against corrosion, fretting, and resists salt water.

Check oil compatibility with plastics

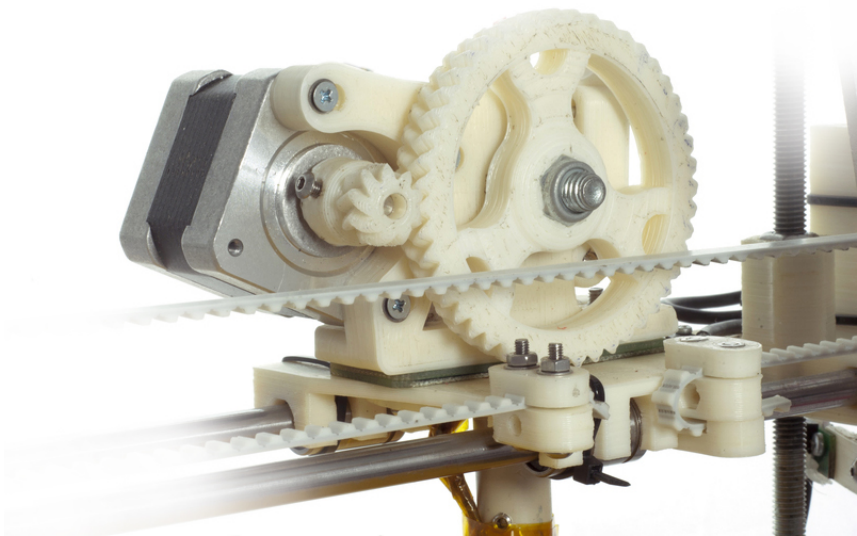
A Guide to Oil-Plastic Compatibility

Plastic		Mineral	PAO	Ester	PAG	Silicone	PFPE
Acrylonitrile butadiene styrenes	ABS	🟡	🟡	🔴	🔴	🟢	🟢
Polyamides (nylons)	PA	🟢	🟢	🟢	🟡	🟢	🟢
Polyamide-imides	PAI	🟢	🟢	🟢	🟢	🟢	🟢
Polybutylene Terephthalates (polyesters)	PBT	🟢	🟢	🟡	🟡	🟢	🟢
Polycarbonates	PC	🟡	🟡	🔴	🔴	🟢	🟢
Polyethylenes	PE	🟡	🟡	🟡	🟡	🟢	🟢
Polyetheretherketone	PEEK	🟢	🟢	🟢	🟢	🟢	🟢
Phenol-formaldehyde (phenolics)	PF	🟢	🟢	🟢	🟢	🟢	🟢
Polyimides	PI	🟢	🟢	🟢	🟢	🟢	🟢
Poly-oxymethylenes (acetals)	POM	🟢	🟢	🟢	🟡	🟢	🟢
Polyphenylene oxides	PPO	🟢	🟢	🔴	🔴	🟢	🟢
Polyphenylene sulfides	PPS	🟢	🟢	🔴	🔴	🟢	🟢
Polysulfones	PSU	🟢	🟢	🔴	🔴	🟢	🟢
PolyPropylene	PP	🟡	🟡	🟡	🟢	🟢	🟢
PolyTetraFluoroEthylene	PTFE	🟢	🟢	🟢	🟢	🟢	🟢
Polyvinyl chlorides	PVC	🟡	🟡	🔴	🔴	🟢	🟢
Thermoplastic Polyurethane	TPU	🟢	🟢	🟡	🟡	🟢	🟢

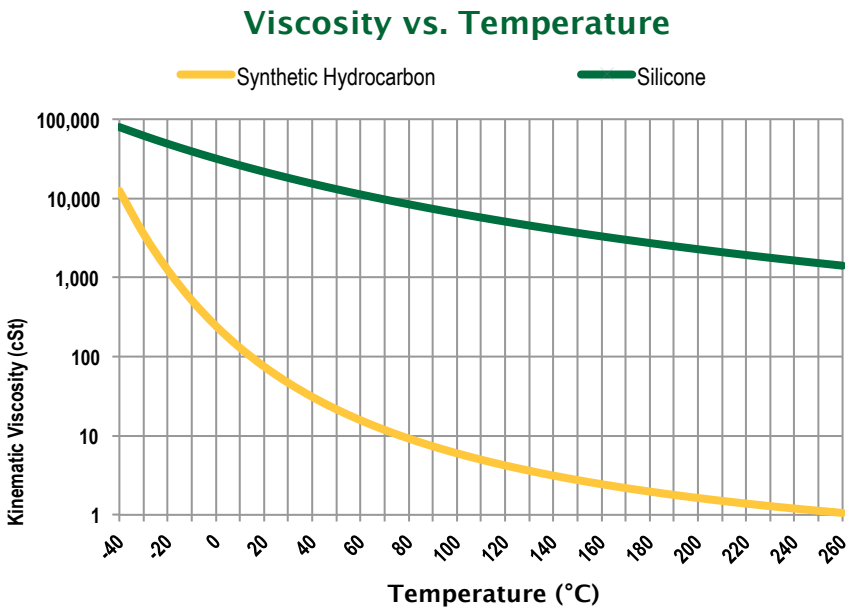
🟢 Should be safe 🟡 May or may not work 🔴 Don't try it

Check oil and plastic compatibility

- PAO is safe with nearly all plastics, but they may or may not work with PPE, PP, or PVC.
- Silicone and PFPE are safe with any plastic.
- PAGs and esters don't mix with polycarbonates, polyphenylene oxides and sulfides, polysulfones, polypropylene, and polyvinyl chlorides.



Viscosity of the Oil: *Key Characteristic of a Damping Grease*



A Note on Viscosity Index
The viscosity of an oil gets thicker at low temperatures and thinner at higher temperatures. Some oils, like silicone, have a higher Viscosity Index, that is, there is less change in viscosity as temperatures change.

Viscosity and Temperature

- The right viscosity ensures the oil does not get too thin to prevent wear at high temperatures or too thick to lubricate properly at low temperatures.
- Higher viscosity oils, required components of damping greases, have a higher "Viscosity Index," indicating there is less change in viscosity over temperature.

Viscosity and Load

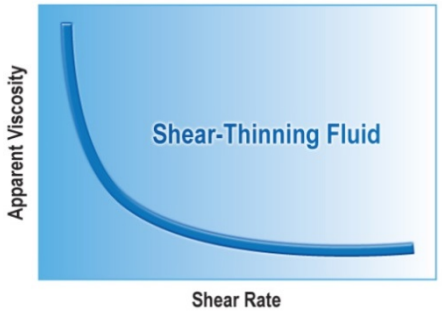
- Heavier loads require higher viscosity oils to ensure enough lubricating oil film remains between two surfaces.
- Lubricity additives and solid lubricants can enhance the natural viscosity of the oil and component performance.

Viscosity, Speed, and Power

- High speed and low power devices require lighter viscosity oils to reduce drag while still providing the lubricant film needed for lifetime wear protection. Because of their high viscosity, damping greases are usually not suitable for "flea-power" components.

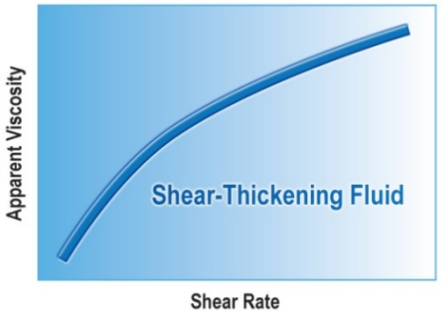
Last step: *Check and test Apparent Viscosity of damping grease*

Thixotropic Grease: Shear-Thinning
Viscosity Decreases with Shear



The viscosity of a grease changes when sheared.
Apparent Viscosity, reported in centipoise, gives a design engineer an indication of the "shear quality" of a grease at specific temperatures.
(Water is about 1 cP. Wood putty is about 1 million cP.)

Dilatant Grease: Shear-Thickening
Viscosity Increases with Shear



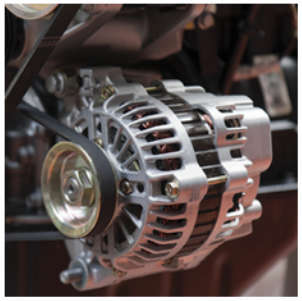
Apparent vs. Kinematic Viscosity

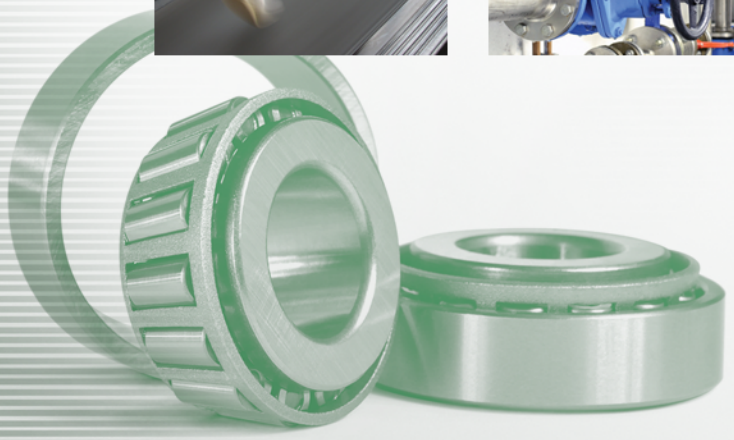
- **Kinematic Viscosity** is a characteristic of the base oil. The viscosity of oil may change with temperature or compression but, typically, ***is not affected*** by shear.
- **Apparent Viscosity** is a characteristic of the grease. The viscosity of grease ***is affected*** by shear. It will become thinner or thicker.
- **Thixotropic greases** become less viscous when sheared, like butter stirred at room temperature.
- **Dilatant greases** become more viscous when sheared, like water and flour stirred at room temperature.

Think shear-ability for damping greases

- To deliver precise motion and noise control under all operating conditions, the Apparent Viscosity of a damping grease must remain fairly uniform. Too thick, and the parts are sluggish. Too thin, and the parts are loose and noisy.
- Part testing will qualify the grease or provide data for re-formulation to meet operating requirements. Pre-qualification of the grease at extreme temperatures is recommended prior to prototype testing.

Beyond damping, consider grease for sealing and conductivity





Grease provides a protective seal for your part

- Seals out water, contaminants, corrosive gases, and chemicals.
- Resists water washout.
- Helps to ensure aged or deteriorated elastomer seals keep working. Also makes them easier to install and remove.

Conductive greases can extend bearing life

- Electrically conductive greases serve as a ground, allowing static discharge to pass through ball bearings instead of pitting the rolling elements or creating grooves in the raceway — both of which decrease operating life.
- Some examples: Ball bearings in computers, printer rolls, toner cartridges, and treadmills, where static discharge may use the bearing as a ground, can benefit from a conductive grease.

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